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Attachment to

6

R11F-300 ENGINE

Technical Description

MIG 21 Engines

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РІІФ-300 ENGINE

TECHNICAL DESCRIPTION

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РІІФ-300 ENGINE

TECHNICAL DESCRIPTION

Book contains 71 sheets

CONTENTS

P11Φ-300 ENGINE SPECIFICATIONS

General Data

1. Engine designation	P11Φ-300
2. Engine type	Turbo-jet, two-shaft, with afterburner
3. Compressor	Axial, 6-stage, two-spool (3+3)
4. Combustion chambers:	Individual, straight-flow, accommodated in common housing
Number	10 pieces
Numbering	left-hand, starting from upper left-hand chamber (looking fwd)
5. Turbine	Axial, 2-stage, two-shaft; 2nd stage shrouded
6. Jet nozzle	Adjustable, variable duty; diameter of throat varies within 526 - 680 mm
7. Arrangement of engine accessories	Lower
8. Direction of rotation of rotors	Counter-clockwise (as viewed from jet nozzle end)
9. Engine overall dimensions:	
(a) length	4600 mm

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(b) diameter of turbine casing ... 772 mm
(c) diameter of afterburner
on shroud ..... 9 6 mm
(d) maximum height complete with
accessories ..... 1605 mm

10. Dry weight of engine with
afterburner ..... Not over 1 65$^{+2}_{-}$%

Note: Dry weight does not include aircraft accessories and assemblies delivered along with the engine.

11. Engine weight, as delivered ..... Not over 1147.5 kg
+2%

Note: The shipping weight of the engine does not include the weight of the oil inserted for corrosion-preventive treatment, and the weight of the auxiliary parts.

12. Engine mounting on aircraft ..... See Chapter X

13. Engine is furnished with:

(a) automatic autonomous starting system providing for push-button starting of engine;

(b) fuel system incorporating main fuel and starting fuel manifolds;

(c) lubricating oil system;

(d) compressor intake fairing anti-icing device providing for normal operation of the engine at any atmospheric conditions;

(e) afterburner with variable duty jet nozzle and dual main fuel manifold;

(f) control system incorporating panel for control of ratings (ПУРТ);

(g) flame igniter oxygen supply system, providing for reliable starting at high altitudes;

(h) system of air bleeding. Amount of air bled from the compressor at maximum engine speed and at standard atmospheric conditions ..... 860 kg/hr

14. Guaranteed service life of engine
up to first overhaul ..... Refer to Service Log

- including operation at maximum and augmented ratings for not more than ..... 30 hours

Note: When calculating the entire operating life of the engine, engine running time on the ground is considered to be equal to 2.5% of the entire operating life. If the engine running time on the ground exceeds 2.5% of the service life, the subsequent operation should be calculated 1 hr per hr.

Parameters of Jet Nozzle Exhaust Area at Main Ratings

1. Full augmented rating ..... 680 mm
2. Minimum augmented rating .... 610^{+15} mm
3. Maximum rating ..... 526^{+14} mm
4. Normal rating ..... 526^{+14} mm
5. Cruising rating ..... 526^{+14} mm
6. Idling rating ..... 680 mm

Engine Control

1. Engine control is accomplished by means of the control lever, through the medium of the control unit.

The control unit consists of regulating fuel pump НР-21Ф and ratings control panel ПУРТ-1С, connected by means of a link. The control system provides for operating the engine at the following ratings:

(a) idling rating, which is switched on by setting the engine control lever against the idling rating stop;

(b) ratings from idling to maximum, which are switched on by shifting the engine control lever from the idling rating stop to the maximum rating stop;

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(c) maximum rating, which is switched on by setting the engine control lever against the maximum rating stop;

(d) minimum augmented rating, which is obtained by setting the engine control lever against the minimum augmented rating stop;

(e) partial augmented ratings, which are switched on by moving the engine control lever from the minimum augmented rating stop to the full augmented rating stop;

(f) full augmented rating, which is accomplished by setting the engine control lever against the full augmented rating stop;

(g) engine stopping, which is accomplished by setting the engine control lever against the CUT-OFF (CTOH) stop.

2. The jet nozzle is of variable duty type providing for control of augmentation; it is actuated with the aid of three hydraulic cylinders.

Purpose	Changing of jet nozzle exhaust area for setting required engine rating
Control system	Electro-hydraulic type
Operating fluid	Hydraulic fluid AMP-1[illegible], Specifications MIL-10-58, or AMP-10, State Standard 6794-53
Hydraulic fluid pressure in system	180 - 215 kg/sq.cm.

Starting System

1. Starting system type	Automatic, autonomous, electric, with voltage switched over from 24 to 48 V

2. The starting system provides for:

(a) engine starting or cranking at a temperature of -20 to +50°C three times in succession, without boost-charging of storage batteries;

(b) engine starting or cranking at a temperature of -40 to +50°C five times in succession, using a ground power supply

source of the AKA-2.8 type, with starter not requiring any cooling in between the operating periods;

(c) engine starting during flight at any atmospheric conditions, at altitudes of up to 12,[illegible] m. (with oxygen supply) and up to [illegible] m. (without oxygen supply).

3. Starting system components	Starter-generator, starting equipment, starting fuel system, flame igniters, oxygen supply system, starting fuel control unit incorporated in pump HP-21[illegible], electromagnetic valve controlling fuel feed at starting, starting fuel ignition system, air blow-off valves (2 pieces)

Starter-Generator

Type	PCP-CT-12000BT
Purpose	Is used as a starter during engine starting. With engine running, is employed as a D.C. generator. Change over from starter to generator duty is accomplished automatically at 32 +2% of high-pressure rotor normal rating or by timer within 44.6 ±1.2 sec.
Number	1 piece
Direction of rotation	Counter-clockwise
Gear ratio	
At starter duty	2.249
At generator duty	2.249
	1.344

Starter-generator may be operated as a starter not more than 5 times in succession.

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Starting Equipment
(is not delivered with engine)

Aircraft power supply source (storage batteries)

Type	15СЦС-45
Number	2 pieces
Purpose	Is employed as a power source during engine starting
Starting relay box	КПР-15А installed on aircraft (is not supplied along with the engine)
Ground power supply source switch box	КПА-4 (installed on ground power supply source; is not delivered along with the engine)

Timer

Type	ПВ7-44-5 (installed on aircraft; is not delivered along with the engine)
Purpose	Provides for successive operation of the electric starting equipment within the time period of 44.0 ±1.2 sec.

Starting Fuel System

Purpose	During engine starting on ground and in air system provides for gasoline supply into flame igniters and for igniting combustion chambers
Starting fuel used	Aviation gasoline Б-70, State Standard 1012-54
Fuel consumed in one starting	Not over 0.3 lit.

Components incorporated in starting fuel system:

(a) Starting fuel tank	1 piece (mounted on aircraft)
(b) Filter	1 piece (installed on aircraft)
(c) Starting fuel pump (installed on the aircraft)	

Type	ПНТ-10-9М, gear type, driven by electric motor
Number	1 piece
Output	40+6 lit. per hour at a pressure of 2+.2 kg/sq.cm., with V = 24 V and H = 0
Pressure should be adjusted at	2 ±0.2 kg/sq.cm. (with no air pressure supplied into tank and at voltage of 25 -2 V, as read off aircraft voltmeter)
Starting fuel tank pressurization value	.4 ± .05 kg/sq.cm. (provided by Manufacturing plant)
(d) Electromagnetic starting fuel valve	
Type	МКПТ-9
Number	1 piece
(e) Flame igniters	
Type	External, with low-voltage ignition system and oxygen supply
Number	2 pieces

Flame Igniter Oxygen Supply System

Purpose	To supply additional amount of oxygen to flame igniters for more effective ignition of main burners when starting engine in flight

Components incorporated in oxygen supply system:

Oxygen bottle	Not less than 2 lit. capacity (arranged on aircraft), 1 piece
Oxygen pressure reducer	КЗ8; outlet pressure amounting to 9 - 11.5 kg/sq.cm. (arranged on aircraft), 1 piece
Electromagnetic oxygen valve	1 piece (mounted on aircraft)
Non-return oxygen valve	1 piece

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Oxygen pressure forward of flame igniters	4.5 - 5.5 kg/sq.cm.
Electromagnetic fuel supply valve:	
Purpose	Supplies additional amount of fuel (64 ±3 l/hr) for acceleration of starting procedure on ground; fuel is started to be supplied within 25 sec. after button STARTING (LAUNCH) is pressed; additional fuel supply is discontinued as soon as high-pressure rotor reaches speed amounting to 48% of its normal r.p.m.
Type	ЭКПТ-9Ф
Number	1 piece
Starting fuel ignition system	Low-voltage, employing erosion-type surface discharge spark plugs
Air blow-off valves:	
Purpose	Discharge part of air into atmosphere to prevent engine from stalling at starting on ground
Type	Hydraulic
Number	2 pieces
4. Permissible gas temperature aft of turbine during starting	Not over 650°C
5. Time required for engine to gain idling speed from the moment starting button is pressed:	Not over 60 sec.

- afterburner may be turned on within not less than 90 sec. after pressing the starting button;

Notes: 1. During autonomous starting, the time period required for reaching the idling speed may be increased to 100 sec.

2. In case the maximum or augmented speed is reached within 90 sec. after pressing the starting button, gas temperature aft of the turbine is allowed to be increased to 720°C (for not more than 5 sec.).

Fuel System

1. Grade of fuel	
(a) main and afterburner	T-1, State Standard 4138-49 T-2, State Standard 8410-57 TC-1, State Standard 7149-54

Note: Engine may operate on fuel T-2 for not more than 50 hours.

2. Fuel booster pump	ДЦН13АТ
Type	Centrifugal, with permanent-pressure valve
Direction of rotation	Counter-clockwise
Gear ratio	1.344
Pressure upstream of booster pump at idling rating	1.8 +5.4 kg/sq.cm. abs
	1.8 +3. kg/sq.cm. abs
Short-time (with aircraft deenergized) pressure upstream of pump (up to 6000 m. for TC-1 and T-1)	Not less than 0.46 kg/sq.cm. abs
(Up to 4000 m. for T-2)	Not less than 0.6 kg/sq.cm. abs
3. Fuel pressure upstream of high-pressure fuel pumps (main and afterburner)	2.4 - 3.8 kg/sq.cm. abs
Short-time pressure rise at idling rating	Up to 4.8 kg/sq.cm.
	Not less than 1.4 kg/sq.cm.
4. Main fuel regulating pump:	
Type	НР-214, plunger, with variable low-pressure rotor speed governor, and with device for limiting fuel

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	pressure increase at acceleration; pump is furnished with hydraulic decelerator, starting fuel control unit, by-pass valve, and distributing valve. Pump rotor is driven by engine high-pressure rotor
Purpose	Meters fuel supplied into combustion chambers to provide for maintaining predetermined engine speed at sustained ratings and intermediate ratings
Direction of rotation	Clockwise
Gear ratio	2.76
Starts regulating engine speed automatically	at 85 -2% of normal rating, or at 9500 - 200 r.p.m.
Maximum fuel output (at Π_2 = 11,500 r.p.m.)	Not less than 7000^{+200} lit/hr
Minimum fuel output (at Π_2 = 10,000 r.p.m.)	360 ±15 lit/hr
5. Afterburner fuel regulating pump:	
Type	HP-22Φ; plunger type with afterburner fuel regulator and barostatic fuel supply limiter; pump is furnished with afterburner valve, high-pressure rotor speed transmitter with limiter, and control unit EV-4B
Purpose	Meters fuel delivered into afterburner, with P_2/P_4 ratio maintained at the same value; limits fuel delivery depending on compressor outlet pressure; limits maximum r.p.m. of high-pressure rotor
Direction of rotation	Clockwise
Gear ratio	2.57

Maximum fuel output (at Π_2 = 11,150 r.p.m.)	Not less than 10,500 -400 lit/hr
6. Pressure of fuel in pilot manifold of engine main fuel system	Not over 9½ kg/sq.cm.
7. Pressure of afterburner fuel at HP-22Φ pump outlet	Not over 90 kg/sq.cm.
8. Main burner:	
Type	Centrifugal, two-stage, duplex
Number	18 pieces
9. Starting burner:	
Type	Centrifugal, single-stage
Number	2 pieces
10. Afterburner fuel injector:	
Type	Centrifugal, single-stage
Number	102 pieces
(a) in larger manifold	60 pieces
(b) in smaller manifold	42 (including 2 starting injectors)
11. Filter at main and afterburner fuel inlet	Gauze, having 16,900 meshes per sq.cm.; incorporated in unit 3570
12. Fuel temperature at high-pressure pump inlet:	
continuous	Not over +80°C
short-time (10 min. per 1 operating hour)	Not over +120°C

Lubrication System

1. Type	Close-circuit, autonomous
2. Oil grade used	MK-8, State Standard 6457-53
3. Oil consumption	Not over 1.2 lit/hr
4. Pressure in oil line:	
(a) at all ratings (idling rating exclusive)	3.5 +0.5 kg/sq.cm.
(b) at idling rating	Not less than 1.0 kg/sq.cm.

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Note: At altitudes exceeding 1[illegible] m. oil pressure may drop [illegible] kg/sq.cm.

5. Oil temperature at engine inlet — Not less than -40°C

Oil temperature at engine outlet — Not over +145°C

Note: Oil temperature is measured during experimental tests carried out in compliance with a special schedule.

6. Oil pumps:

(a) delivery oil pump:

Type	Gear-type
Number	1 piece
Direction of rotation	Clockwise
Gear ratio	3.168
Delivery at normal rating with back pressure amounting to 3.5 +0.2 kg/sq.cm. and oil temperature of +60 - 75°C	Not less than 50 lit/min.

(b) oil pump for scavenging oil from accessory wheel case and from central and rear supports:

Type	Gear-type, three-section
Number	1 piece
Direction of rotation	Clockwise
Gear ratio	3.168
Delivery at normal rating with back pressure amounting to 0.5 - 0.8 kg/sq.cm. and oil temperature of +60 - 75°C	Not less than 120 lit/min.

(c) pump for scavenging oil from front support:

Type	Gear-type
Number	1 piece

Direction of rotation	Clockwise
Gear ratio	4.461
Delivery at normal rating with back pressure amounting to 0.5 - 0.8 kg/sq.cm. and oil temperature of +60 - 75°C	Not less than 12 lit/min.
7. Oil pressure gauge	MM-8T
8. Fuel and oil unit consisting of fuel-cooled oil cooler, low-pressure fuel filter and oil tank	
Type	317C
Purpose	Cooling of oil at any of engine ratings
Oil tank capacity	16 lit.
Amount of oil inserted in tank	12 ±0.5 lit.
Minimum amount of oil allowing for normal operation of engine	7 lit.

9. Provision has been made in the engine oil system for draining oil from all lower points of the oil cooler and of the engine wheel case, as well as for breathing the engine through the centrifugal breather with barostatic valve, ensuring normal operation of the oil system at high altitudes.

10. The engine oil system provides for normal operation of the engine irrespective of interruptions in oil supply (during inverted flight, etc.) amounting to not more than 17 sec.

Ignition System and Electrical Equipment

1. Type of ignition system	Electric, low-voltage
2. Booster coil unit:	
(a) serving combustion chambers number	KMN-114M
number	2 pieces
(b) serving afterburner	KMN-114M (installed on aircraft)
number	1 piece

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3. Starting spark plugs:	Shielded, surface discharge
serving combustion chambers	СШН-4-3
number	2 pieces
serving afterburner	СЗ-21Д5
number	2 pieces (including 1 standby)
4. Generator regulating equipment	РУГ-82 and ДМР-400Д (are not delivered with engine; installed on aircraft)
5. Afterburner control unit with relay T, type ТКЕ24ПДТ	КА913Д (is not delivered with engine; installed on aircraft)
Purpose	Causes afterburner to be turned on and cut off automatically
Number	1 piece
6. Ratings control panel:	
Type	ПУРТ-1Ф
Number	1 piece
7. Variable duty jet nozzle control system:	
Type	ЭРСУ-1А
Components:	
Rheostatic transmitter	ДР-3А
Regulating rheostat	Р-1
Feed-back transmitter	ДОС-1А
Pulse delivery box	КРС-1 (installed on aircraft; is not delivered with engine)
Electro-hydraulic switch	ГА-164М (installed on aircraft)
8. Control unit:	
Type	БУ-4Б
Number	1 piece

Chapter I

COMPRESSOR

The engine compressor (Fig.6) is an axial, two-spool, six-stage type.

The compressor comprises a stator mounting fixed vanes of the guide vane assemblies, and two rotors: a low-pressure rotor and a high-pressure rotor; each of the rotors consists of three stages.

The first four stages of the compressor are supersonic, as regards the relative velocity of the air entering the rotor blades; the air at the guide vane assembly inlet has a subsonic velocity.

The rotor blades impart energy to the air, simultaneously slowing down its axial velocity; the guide vane assemblies straighten the air stream until it flows in the axial direction, and cause an increase in the axial velocity.

This arrangement provides for satisfactory operation of both the rotors and the guide vane assemblies.

Stator

The compressor stator (Fig.6) consists of distance ring 1, front casing 3, casing 6 of second stage guide vane assembly 5, middle casing 8, casing 12 of the fourth and fifth stage guide vane assemblies, and rear casing 14. All the casings are thin-walled, light structures fabricated in steel which allows for the use of welded guide vane assemblies giving reliable performance.

The casings are coupled to each other by means of bolts, passed through flanges. Neither of the casings, exclusive of

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3. Starting spark plugs:	shielded, surface discharge
serving combustion chambers	СПН-4-3
number	2 pieces
serving afterburner	СЗ-21Д5
number	2 pieces (including 1 stand-by)
4. Generator regulating equipment	РУГ-82 and ДМР-400Д (are not delivered with engine; installed on aircraft)
5. Afterburner control unit with relay T, type ТКЕ24ПДТ	КА№13Д (is not delivered with engine; installed on aircraft)
Purpose	Causes afterburner to be turned on and cut off automatically
Number	1 piece
6. Ratings control panel:	
Type	ПУРТ-1Ф
Number	1 piece
7. Variable duty jet nozzle control system:	
Type	ЭГСУ-1А
Components:	
Rheostatic transmitter	ДР-3А
Regulating rheostat	Р-1
Feed-back transmitter	ДОС-1А
Pulse delivery box	КЭС-1 (installed on aircraft; is not delivered with engine)
Electro-hydraulic switch	ГА-164М (installed on aircraft)
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